
TRANSPORTATION SYSTEMS MANAGEMENT AND OPERATIONS



TSMO

STRATEGIC FRAMEWORK FOR PENNSYLVANIA



pennsylvania
DEPARTMENT OF TRANSPORTATION

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WHAT IS TSMO?

“We cannot build our way out of congestion.” This is the refrain we have often heard over the last ten years. We simply do not have the funds to address our struggle with congestion through capacity-adding projects that provide small returns on our investment dollar. The transportation project planning process has traditionally consisted of forecasting future traffic volumes to determine the location of capacity deficiencies within a roadway network. While it is important to maintain an acceptable level of capacity on the roadways, these “bottlenecks” on average only account for 40% of congestion levels.

So how do we address congestion? Operations. This approach is not new and we have been implementing elements of operational strategies for years under other labels such as intelligent transportation systems and corridor modernization. Though until now, we have not had a formalized and unified approach to ensure that all aspects of the program are properly addressed.

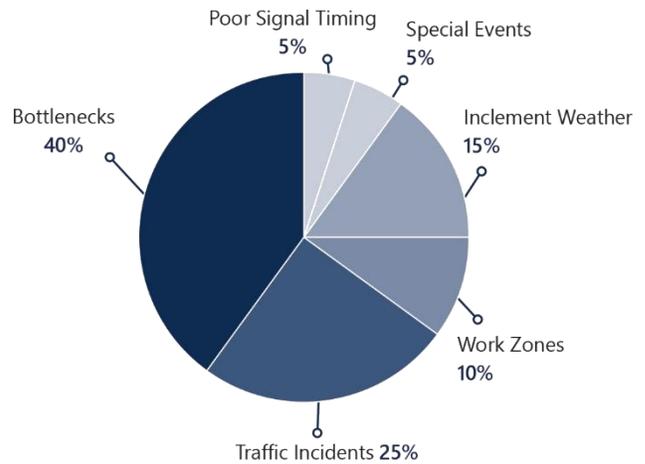
Transportation agencies across the country have begun implementing Transportation Systems Management and Operations (TSMO) programs, which are defined by the Federal Highway Administration (FHWA) as “a set of integrated strategies to optimize the performance of operations on existing infrastructure through implementation of multimodal, cross-jurisdictional systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of a transportation system.” In simplest terms, TSMO is a way to increase reliability and mobility of our roadways by using a wide-range of strategies rather than adding capacity to manage congestion.

While the end-goal is to decrease congestion and increase reliability for the everyday driver, there are deeper issues that need to be resolved in order to ensure this program is successful. Congestion causes are classified as either recurring or non-recurring. Recurring congestion is generally expected and familiar to the motorist on a daily basis (bottlenecks and poor signal timing), whereas non-recurring congestion is a result of circumstances that may not be expected (work zones, inclement weather, traffic

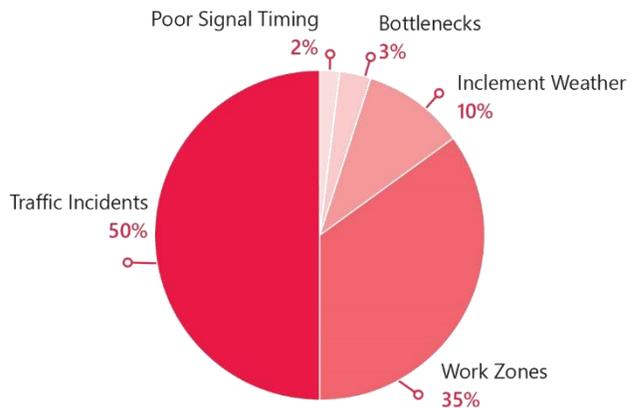
incidents, and special events). All causes of congestion can be addressed to some degree with improved operations.

A key part of the TSMO Program Plan will be identifying the activities and projects necessary to meet PennDOT’s adopted mission, vision, goals, and objectives. The Pennsylvania TSMO program will not only address the congestion and reliability issues on the roadways, but will also provide strategies to improve business processes, performance measurement, culture, organization, staffing, and collaboration to sustain the program.

URBAN CONGESTION PERSPECTIVE



RURAL CONGESTION PERSPECTIVE



WHAT IS TSMO? (CONTINUED)

There is a toolbox of operations solutions to address all aspects of the congestion pie chart with varying cost and deployment requirements. The goal should be to right-size the improvements with the ability to measure their effectiveness. Several operations solutions that PennDOT is considering are listed below.

TSMO Solution	Causes of Congestion					
	Recurring Congestion		Unplanned Events		Planned Events	
	Bottlenecks 	Poor Signal Timing 	Traffic Incidents 	Inclement Weather 	Work Zones 	Special Events 
Bridge De-icing				X		
Closed Circuit TV Cameras (CCTV)	X		X	X	X	X
Dynamic Curve Warning			X	X		
Dynamic Message Signs (DMS)	X		X	X	X	X
Dynamic Rerouting	X		X		X	X
Flex Lanes	X		X		X	X
Freeway Service Patrols			X		X	X
Integrated Corridor Management	X	X	X	X	X	X
Junction Control	X		X		X	X
Managed Lanes	X					
Queue Warning	X		X		X	X
Ramp Metering	X		X			X
Road Weather Info. Systems (RWIS)				X		
Smart Corridor Initiatives	X	X	X	X	X	X
TIM Teams			X			
Traffic Incident Detection			X			
Traffic Management Center	X	X	X	X	X	X
Traffic Signal Enhancements		X				
Transit Signal Priority		X				
Traveler Information	X		X	X	X	X
Variable Speed Displays	X		X	X	X	

These solutions are intended to deliver cost effective and targeted ways to address congestion issues within Pennsylvania. While they have been successfully implemented throughout the country and have served as examples of decreasing congestion without the addition of capacity, there are also institutional issues that need to be addressed to ensure they can be planned and programmed effectively. The TSMO Program Plan will focus not only on the benefits of operations solutions but also on identifying those institutional issues requiring attention.

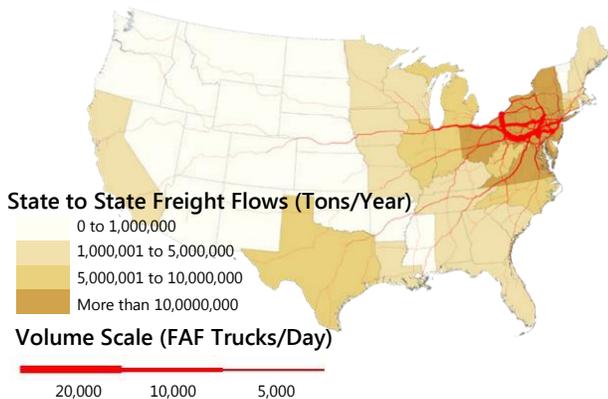
WHY TSMO? THE MOBILITY ISSUE

In the context of a transportation system, mobility is the movement of people and goods as safely, efficiently, and reliably as possible. As traffic volumes continue to increase at a rate that exceeds available capacity, congestion follows, impeding mobility.

Nationally, delays from congestion caused an extra 42 hours of travel and required the purchase of an extra 19 gallons of fuel in 2014, totaling \$960 in congestion costs (compared to \$400 in 1982) nationwide according to the Texas Transportation Institute (TTI) 2015 Urban Mobility Scorecard.

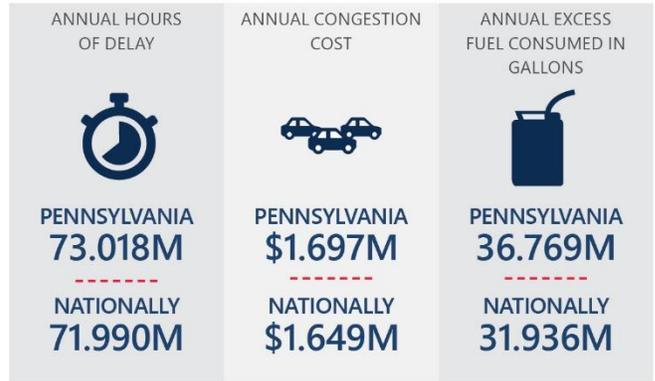
Data from the Scorecard was also analyzed to determine how congestion levels in Pennsylvania stack up against the national perspective. The results indicate that Pennsylvanians spend more time in congestion, spend more money on congestion, and burn more excess fuel than the national average in both rural and urban areas. Additionally, the Philadelphia metropolitan area was identified as the eighth highest city in the United States in terms of travel delay and excess fuel consumed.

Decreased mobility in Pennsylvania affects both passenger cars and the freight industry. Approximately 87.8 billion ton miles of truck shipments use the highway system in Pennsylvania. According to Pennsylvania’s 2015 Transportation Performance Report, Pennsylvania moves 9% of the nation’s goods (by value in dollars) and freight demand is expected to grow by 66% by 2040.



PENNSYLVANIA’S CONGESTION RELATED COSTS ARE HIGHER THAN THE NATIONAL AVERAGE

URBAN (≥ 500,000 PEOPLE)



RURAL (< 500,000 PEOPLE)



Pennsylvania has three ports that send and receive shipments to the Atlantic, Gulf of Mexico, and Great Lakes, as well as six International Airports, and four Class 1 Railroads. Additionally, Pennsylvania is within 24 hours of 60% of the US and Canada population, and 6 of the 10 largest US markets. Philadelphia Port has nearly completed a \$392 million Delaware River Main Channel Deeping to support larger ships using the Panama Canal Expansion, and an additional \$300 Million is being invested to improve terminals and auto processing facilities. Pennsylvania is the keystone state in regional and national freight logistics and critical to providing a reliable transportation system for the nation’s economy.

WHY TSMO? THE SAFETY ISSUE

Congestion has a direct impact on safety. When a limited access highway is operating at free-flow conditions, rear-end crashes are nearly non-existent. A rear-end crash typically occurs when free-flow vehicles encounter congestion resulting from typical rush hour delay, construction projects, or traffic incidents. A study performed by the University of California Irvine found that rear-end crashes were the only statistically significant crash type that occurred during congested flow conditions.

According to PennDOT’s crash statistics, rear-end crashes on limited- access highways in Pennsylvania have been increasing since 2006, with notable increases of 12% from 2009-2010 and 18% from 2014-2015, indicating an increase in crashes cause by congestion on limited-access highways.

Additionally, congestion and delays resulting from traffic incidents increase the likelihood of a secondary crash. Research has shown that the likelihood of a secondary crash increases by 2.8% for each minute the primary incident continues to be a hazard. Incident clearance times can last anywhere from 30 minutes to several hours, and therefore a secondary crash is highly probable in many cases.

Reducing the number of rear-end crashes, minimizing clearance time during traffic incidents, and providing safer and more efficient work zones are some of the ways TSMO can help make Pennsylvania roads safer while reducing congestion caused by work zones and traffic incidents.

INCREASE IN PENNSYLVANIA CONGESTED-RELATED CRASHES
Rear-End Crashes on Limited-Access Highways

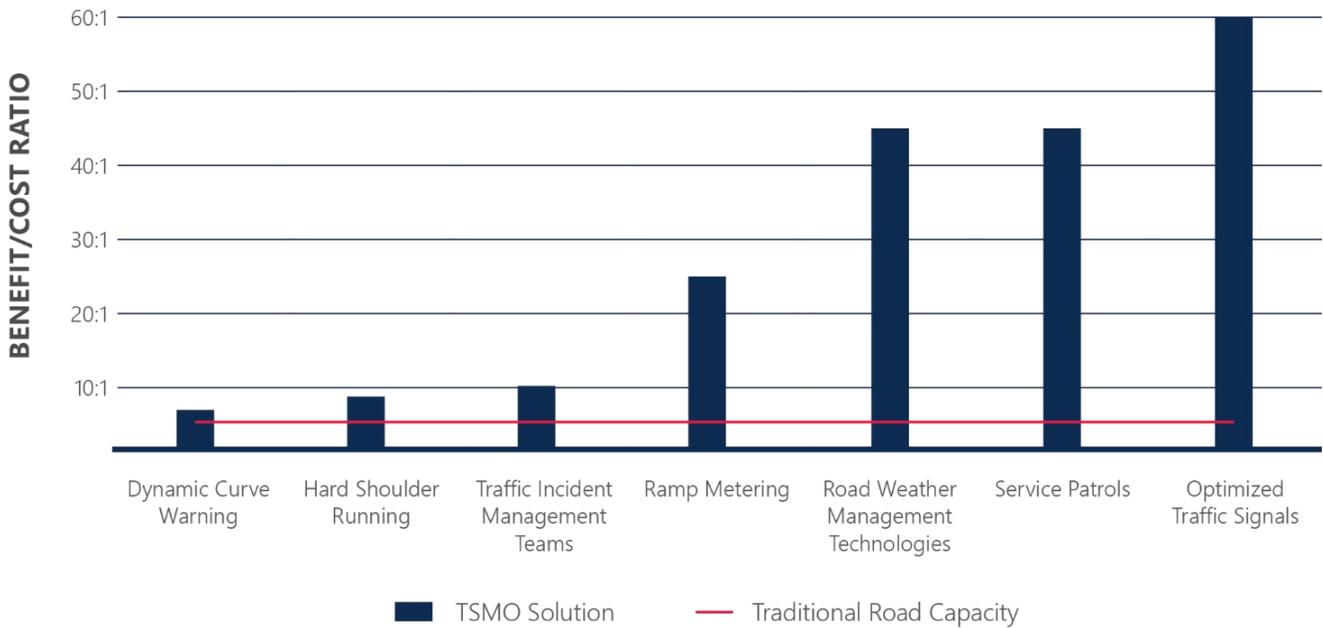


WHY TSMO? THE FUNDING ISSUE

With the level of delay and congestion experienced by both passenger cars and commercial vehicles along the highway system, Pennsylvania must be proactive in dealing with recurring and non-recurring congestion. TSMO offers a potentially quicker and well-balanced approach to improve and optimize the performance of the current transportation network and assets in Pennsylvania. TSMO often addresses the root problem more effectively than capacity adding projects alone.

State agencies are realizing that large capacity adding projects and small scale ITS projects are not always the best solutions to mitigating congestion. In fact, capacity adding projects generally cost more and provide a lower return on investment compared to operational strategies. As TSMO strategies target specific causes of congestion at a specific location, the applications are extremely cost effective with a benefit/cost ratio as high as of 60:1.

BENEFIT/COST RATIO OF OPERATIONS SOLUTIONS VERSUS CAPACITY ADDING PROJECTS



WHY TSMO? THE FUNDING ISSUE (CONTINUED)

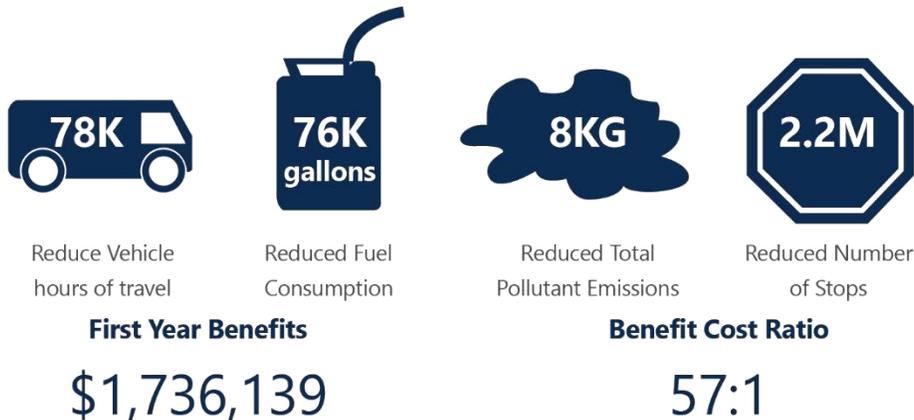
There are many Pennsylvania-specific examples that demonstrate the value of operations projects. A study conducted by Pennsylvania State University reported that the introduction of freeway service patrols on the Penn-Lincoln Parkway in the Pittsburgh metropolitan area had a dramatic effect on incident response and clearance times.

PENN-LINCOLN PARKWAY FREEWAY SERVICE PATROL



Southwestern Pennsylvania Commission’s (SPC) Regional Traffic Signal Program continues to pay dividends for the region. They have now delivered two completed cycles of this important regional program. To date, they have invested over \$8M to improve 501 traffic signals across 63 municipalities, resulting in a yield of \$64 of public benefit for every \$1 spent in terms of reduced delay, vehicular stops, and fuel consumption/vehicular emissions across all intersections in the program. The following graphic illustrates the benefits obtained for a specific corridor in Allegheny County.

ROBINSON TOWN CENTER / SUMMIT PARK DRIVE TRAFFIC SIGNAL RETIMING – SPC



CURRENT STATE OF THE PRACTICE ORGANIZATIONAL STRUCTURE

In Pennsylvania, traffic operations is managed in distinct and sometimes disparate ways. There are four groups within Central Office that are responsible for traffic operations policies and guidance. Two sections (Planning and Operations, and Deployment and Maintenance) are located within the Highway Safety and Traffic Operations Division (HSTOD), and two sections (Winter Operations and Incident Management) are located within the Maintenance Technical Leadership Division (MTLD). Aligning the goals of HSTOD and MTLD as well as maintaining open communication are crucial to undertaking a comprehensive and unified TSMO program.

Existing Central Office Business Areas essential to developing a statewide TSMO Program are: ITS, Traffic Signals, Traffic Incident Management, Work Zones, Traffic Management Centers, Traveler Information, Connected and Autonomous Vehicles, and Winter Weather. Though these groups are part of various sections, coordination will be critical to address safety, mobility, and funding issues and to move up the Capability Maturity Model.

Each of the eleven Engineering Districts houses a traffic engineering unit who collaborate with Metropolitan and Rural Planning Organizations (MPOs/RPOs) to deploy, operate, and maintain TSMO strategies within their respective regions.

Most District Traffic Units report to the Assistant District Executive for Maintenance (ADE-M) while the Traffic Unit in District 6 reports to the ADE for Operations (ADE-O). In addition, the job requirements of the ADE-Ms in the Regional Traffic Management Center (RTMC) districts do not identify operational responsibilities for the entire region.

From an operations standpoint, seven of the eleven engineering districts maintain some level of a Traffic Management Center (TMC). RTMCs are located within four of the districts to ensure 24/7 operations statewide by supporting their member districts throughout the day or during off-hours for a local TMC. Additionally, a Statewide Traffic Management Center (STMC), located in Harrisburg, is responsible for oversight, support, and coordination of issues and needs of statewide significance.

Leveraging the existing RTMC regions as Operations Regions will help join the planning partners with the PennDOT Districts to incorporate TSMO into the overall project development process.

PENNDOT RTMC REGIONS



CURRENT STATE OF THE PRACTICE THE PROJECT DEVELOPMENT PROCESS

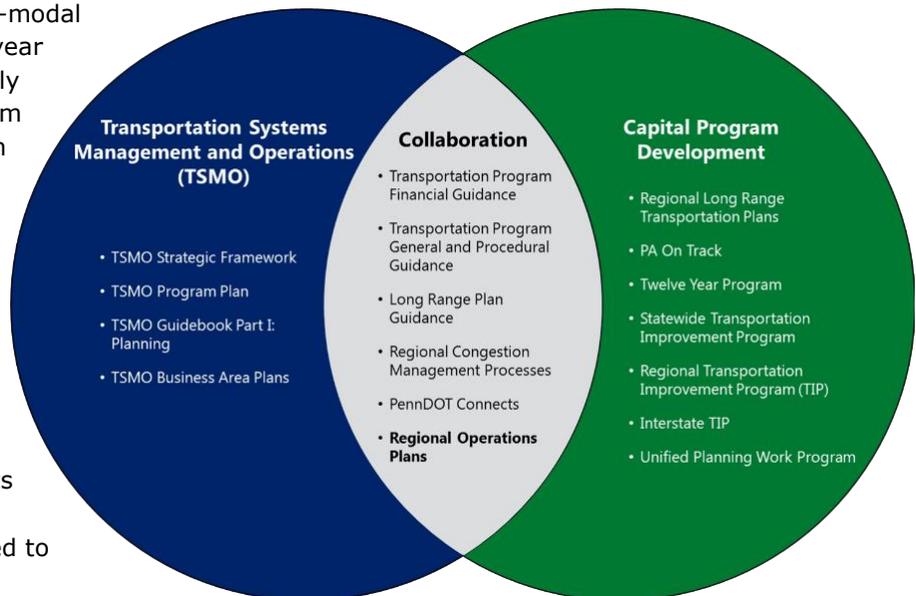
While the mechanism does currently exist for operations to be considered as part of the project development process, it is by reference only through PennDOT’s Long Range Transportation Program (LRTP), and not mandated. Although operations projects or project elements may be identified early in the planning process, they are not always programmed and constructed, which is in large part due to the current lack of operations performance measures. Funding is currently influenced by performance measures such as the International Roughness Index (IRI) and Structurally Deficient Bridge Percentage (SD%). A change in performance measurement can ensure that operations projects or project elements are considered throughout the entire process, beginning with initial project scoping when project extent and cost are determined.

The planning process begins with PennDOT’s Statewide LRTP, known as PA OnTrack. The LRTP is a strategic, multimodal, performance-based plan that advances the planning tools introduced in the State’s 2007 Pennsylvania Mobility Plan and builds upon PennDOT’s vision for transportation in Pennsylvania. The LRTP is used by the Planning Partners to develop their own Regional Long Range Transportation Plans (RLRTP) which are used to identify projects that eventually are put on the Transportation Improvement Program (TIP).

The TIP is used to identify all multi-modal transportation projects within a 4-year period that are considered regionally significant or will utilize funding from the Federal Highway Administration (FHWA). The TIP includes anticipated costs and schedules for all transportation investments and project phases to be advanced over the upcoming four years, advancing the region’s LRTP. The TIP, produced by each MPO and RPO in Pennsylvania is updated every two years and contains the first 4 years of projects that appear in the Twelve-Year Program (TYP). PennDOT is required to

prepare and submit a TYP to the State Transportation Commission (STC) every two years.

While the TIP and the TYP identify funding for all proposed transportation projects, PennDOT currently uses Regional Operation Plans (ROP) to identify, define, and prioritize operationally-focused projects for each region. PennDOT resources, such as the TSMO Guidebook – Part I: Planning, recommend that TSMO projects should be part of the Regional Operations Plan (ROP) to ensure consideration for funding as part of the overall planning process. ROPs are intended to be included by reference within the RL RTP and contain four years’ worth of projects to be programmed into the regional TIP. Previously, ROPs were developed for nine regions throughout the State. However, future ROPs will be prepared by MPOs/RPOs in coordination with PennDOT to coincide with the four PennDOT RTMC regions. The TSMO Program Plan will identify strategies aimed at incorporating the ROPs into the planning process and developing useful performance measures that ensure the recommended operations projects are programmed and constructed.



CURRENT STATE OF THE PRACTICE PENNDOT CAPABILITY MATURITY SELF-ASSESSMENT

PennDOT and other key stakeholders from around the state participated in a Capability Assessment Workshop as part of the second Strategic Highway Research Program (SHRP2) Organizing for Reliability effort. The purpose of the workshop was to establish a baseline for the state’s current level of operations and to identify preliminary actions. The workshop served as the foundation for the current and ongoing TSMO planning efforts. According to FHWA, “the Capability Maturity Model (CMM) process was created to help agencies identify strengths and weaknesses of their existing traffic operations programs, current capabilities associated with various business processes, and actions that could be taken to help move the program to a more advanced level.”

The CMM evaluated key business processes according to a four-level system that identifies the levels of agency capability: performed, managed, integrated, or optimized.

The results of the workshop show PennDOT at levels that are typical for DOT’s nationally. The Implementation Plan developed as part of the Organizing for Reliability effort identified a few high-level actions for PennDOT to focus on. The need for TSMO planning arose as the key strategy across several of these actions and development of a TSMO Strategic Framework and Program Plan have been the focus for PennDOT.



PENNDOT CMM SELF-ASSESSMENT

Dimension	Level 1 Performed	Level 2 Managed	Level 3 Integrated	Level 4 Optimizing
Business Processes				
Systems and Technology				
Performance Measurement				
Culture				
Organization and Staffing				
Collaboration				

TSMO STRATEGIC DIRECTION VISION, MISSION, AND GOALS

TSMO VISION

The vision statement serves as the optimal and desired state

PennDOT's TSMO vision is a less congested, more reliable network.

TSMO MISSION

The mission statement identifies the purpose of the program

The PennDOT TSMO mission is to move people and goods, from Point A to Point B, as efficiently, safely, and reliably as possible.

TSMO GOALS

The goals identify how the success of the program will be measured

Internal (Outputs)

- Move up the Capability Maturity Model (CMM) - Moving up the CMM in some or all of the six dimensions will serve as the internal means to measure the effectiveness of the TSMO Program. PennDOT will perform periodic self- assessments to determine the areas of the TSMO Program that need to be improved and make changes accordingly.

External (Outcomes)

- Mitigate recurring congestion - Focuses on congestion and delays resulting from bottlenecks and traffic signals.
- Maintain mobility during planned events - Focuses on congestion and delays resulting from work zones and special events.
- Minimize traffic impacts of unplanned incidents/events - Focuses on congestion and delays resulting from traffic incidents and inclement weather.

TSMO STRATEGIC DIRECTION HOW TO USE THIS DOCUMENT

The development of the TSMO Program in Pennsylvania will consist of three major elements: TSMO Strategic Framework, TSMO Program Plan (and associated Action Plan), and the TSMO Guidebook. The TSMO Strategic Framework is intended to engage stakeholders and build interest in creating a TSMO program in Pennsylvania by presenting the overarching business case along with the vision, mission and goals.

The TSMO Program Plan will be built from the TSMO Strategic Framework and will present the Capability Maturity Model-based approach to reach the vision.

Part I of the TSMO Guidebook will serve as guidance for planning partners to develop their regional operations plan and PennDOT’s congestion-related

business areas to assist in developing business plans. The Guidebook will also help planning partners identify connections between their current operations planning documents and the TIP, which will help ensure proper planning for operations.



TSMO STRATEGIC FRAMEWORK

This Framework is designed to make the case for TSMO in Pennsylvania to improve mobility and reliability, safety, and funding dedicated to operations. This document is intended to be used by PennDOT, Planning Organizations, and Stakeholders, but should also be used as a public-facing tool to increase awareness on the benefits of TSMO. Each page of this document was designed so that it could be used as a standalone fact sheet to address the What?, Why?, and the Current State of TSMO in Pennsylvania.

TSMO PROGRAM PLAN

The approach is based on needs, strategies, and actions that were created during stakeholder outreach and are specific to the development and advancement of the TSMO program in Pennsylvania. The TSMO Program Plan also includes an Action Plan to advance each CMM dimension by delegating responsibilities to the PennDOT Business Areas. The plan also identifies what dimension it will advance, dependencies with other strategies, and a listing of additional resources needed to accomplish the strategy/action. This document is intended to be used by PennDOT Central Office and Districts to help identify what actions are necessary from business areas and PennDOT Units to advance the CMM.

TSMO GUIDEBOOK

Part I: Planning, seeks to strengthen and provide a clear connection between planning processes such as the Congestion Management Process (CMP), LRTP, ROP, and the TIP. Both standalone TSMO projects as well as the implementation of TSMO solutions in other projects will benefit from a strong connection to the TIP, and, as a result, can be prioritized during project planning. The audience of this document includes the professionals responsible for transportation planning and operations within the state working for or on behalf of PennDOT, Metropolitan Planning Organizations (MPOs), Rural Planning Organizations (RPOs), or local municipalities. It is intended that these stakeholders use this guidance document throughout the development and implementation of their transportation operations plans and programs.